# SYSTEM AND METHOD FOR CAPTURING PRINT INFORMATION USING A COORDINATE CONVERSION METHOD

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## CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 60/431,240, filed December 6, 2002 and U.S. Provisional Application No. 60/491,537, filed August 1, 2003, both of which are incorporated herein by reference in their entireties.

## BACKGROUND OF THE INVENTION

### Field of the Invention

[0002] The present invention pertains to biometric imaging technology, and in particular, to live scanning of prints.

### Background

[0003] Law enforcement, banking, voting, and other industries are increasingly relying upon biometric data for security and identity recognition. This increased reliance has created a demand for highly reliable, efficient biometric imaging systems. In addition, in order to perform further processing operations on captured images, these groups require the captured image data to be in a particular format. In post-processing applications, this format is a rectangular coordinate system format.

[0004] Biometric imaging systems may include, but are not limited to, print imaging systems. Such print imaging systems are also referred to as scanners or live scanners. In conventional biometric imaging systems, an object such as a hand or finger is placed on the outer surface of a platen. The platen surface can be a surface of a prism or another surface in optical contact with an outside surface of a prism. For example, a platen surface can be a surface of

an optical protective layer (e.g., silicon pad) placed on a prism. To produce raw image data representing the biometric print data, an illumination source illuminates the underside of the object. Raw image data representative of valleys, ridges, and other minutiae of a print are then captured.

**[0005]** Conventional live scanners capture raw image data in a rectangular coordinate system format. Thus, both conventional capture and post-processing applications use the same rectangular coordinate system format appropriate for the planar surfaces of a conventional prism and camera.

## BRIEF SUMMARY OF THE INVENTION

**[0006]** The present invention provides an image conversion system that can process raw image data captured in a first coordinate system format and convert the raw image data into a second coordinate system format acceptable by downstream processing systems. In an embodiment, the present invention can convert image data captured in a scan of a non-planar platen surface such as a curved conical prism surface to image data associated with an approximately planar surface of a camera.

**[0007]** The inventors recognized that the use of a single rectangular coordinate system for capture and in post-processing applications limits implementation options for prisms and capturing systems in the biometric imaging system. When a live scanner has a prism that is non-planar, use of a single rectangular coordinate system to capture the raw image data results in distorted or lost information. As a result, the captured raw image becomes less accurate and may introduce significant errors into post-processing operations.

**[0008]** The present invention is directed to a system and method for converting captured image data in a first coordinate system format to a second coordinate system format. In accordance with embodiments of the present invention, the image conversion system includes a receiving module, a coordinate conversion module, and a memory. The image conversion system

can be implemented in a biometric imaging system or as a system external to a biometric imaging system.

[0009] In an embodiment of the invention, the coordinate conversion module calibrates the image conversion system by generating a conversion data array. The conversion data array maps each pixel in a second coordinate system output area to a position in the first coordinate system. After calibration, the receiving module of the image conversion system receives captured image data in a first coordinate system format from a biometric imaging system and stores the captured image data in memory. For each pixel in the second coordinate system output area, the coordinate conversion module retrieves an entry in the conversion data array and one or more samples from the captured raw image data. The coordinate conversion module then interpolates the retrieved samples using weighting based on the retrieved conversion data array entry to obtain the respective pixel value in the second coordinate system.

[0010] Further embodiments, features, and advantages of the present inventions, as well as the structure and operation of the various embodiments of the present invention, are described in detail below with reference to the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS/FIGURES

[0011] The accompanying drawings, which are incorporated herein and form a part of the specification, illustrate the present invention and, together with the description, further serve to explain the principles of the invention and to enable a person skilled in the pertinent art to make and use the invention.

[0012] FIG. 1 shows an image conversion system for converting image data captured in a first coordinate system format to a second coordinate system format in accordance with an embodiment of the present invention.

[0013] FIG. 2 shows a system incorporating an image conversion system in accordance with an embodiment of the present invention.

[0014] FIG. 3 shows a view of a non-planar prism in accordance with an embodiment of the present invention.

[0015] FIG. 4 shows a flowchart depicting a method for converting captured image data in a first coordinate system to an image data in a second coordinate system.

[0016] FIG. 4A illustrates how a subject places a hand on a non-planar prism in accordance with various embodiments of the present invention.

[0017] FIG. 4B shows a position for an illumination source in accordance with various embodiments of the present invention.

[0018] FIG. 4C is a diagram that illustrates radial scan line images captured along an arcuate scan path and stored in an array.

[0019] FIG. 5 shows a flowchart depicting a calibration method.

[0020] FIG. 5A-B are diagrams that illustrate a conversion data array and the relationships between coordinates in polar and rectangular coordinate systems.

[0021] FIG. 6 shows a flowchart depicting a method for converting captured image data in a first coordinate system to an image data in a second coordinate system using system calibration data.

[0022] FIG. 7 and 8 illustrate the relationship between points on a conical platen surface and corresponding points when the conical platen surface is lifted and flattened to a rectangular coordinate space.

[0023] FIG. 9 shows a system incorporating an image conversion system in accordance with an alternate embodiment of the present invention.

[0024] FIG. 10 shows a system incorporating an image conversion system in accordance with an alternate embodiment of the present invention.

[0025] The present invention will now be described with reference to the accompanying drawings. In the drawings, like reference numbers can indicate identical or functionally similar elements. Additionally, the left-most digit(s) of a reference number may identify the drawing in which the reference number first appears.

## DETAILED DESCRIPTION OF THE INVENTION

[0026] FIG. 1 is a block diagram of an image conversion system 150 for converting the raw image data captured in a first coordinate system format into a second coordinate system format in accordance with an embodiment of the present invention. In an embodiment, image conversion system 150 is implemented in software. Persons skilled in the relevant art(s) will appreciate that functions of image conversion system 150 can be implemented in hardware, firmware, or a combination of software and hardware/firmware.

[0027] Image conversion system 150 includes a receiving module 152, a coordinate conversion module 154, and a memory 156. Receiving module 152 is configured to receive captured image data in a first coordinate system format from a live print scanner. The first coordinate system used in capturing the raw image data depends upon the geometry of a prism implemented in the live scanner. For example, in a live scanner having a conical prism, the first coordinate system is a polar coordinate system. The polar coordinate system describes a point in terms of its angle, $\theta$, and distance (i.e., radius, r) from a fixed origin. Thus, the polar coordinate system is ideal for describing non-planar surfaces such as cones. In an embodiment, the polar coordinate system defines the conical platen surface associated with a conical prism.

[0028] Coordinate conversion module 154 is coupled to the receiving module 152 and to memory 156. Coordinate conversion module 154 contains logic to calibrate the image conversion system 150 and logic to convert captured first coordinate system image data to a second coordinate system format. The second coordinate system used in converting the captured data depends upon the format required by downstream processing systems. In an embodiment of the present invention, the second coordinate system is a rectangular coordinate system. In the case of a conical prism, coordinate conversion module 154 converts image data captured in a polar coordinate system format to a rectangular system format. This conversion is described in further detail with respect to FIGs. 4-8.

[0029] FIG. 1 depicts a separate memory 156 coupled to coordinate conversion module 154 and receiving module 152. In an alternative embodiment, memory 156 could be integrated in coordinate conversion module 154. However, the invention is not limited to these configurations. Other configurations for memory 156 are possible as would be appreciated by a person skilled in the relevant art(s).

[0030] FIG. 2 shows a block diagram of a live scanner 200 having an internal image conversion system 150 in accordance with an embodiment of the present invention. Live scanner 200 includes a non-planar prism 220 optically coupled between an illumination source 215 and an electro-optical system 225 and an image conversion system 150 coupled to the electro-optical system. In an embodiment, live scanner 200 also includes a display processing module 280 coupled to the image conversion system 150 and/or the electro-optical system 225.

[0031] Live scanner 200 captures biometric data from objects interacting with non-planar prism 220 and communicates the captured raw image data to image conversion system 150. An exemplary electro-optical system 225 is described in co-pending U.S. Patent Application entitled, "Rotating Optical System Used in a System for Obtaining Print and Other Hand Characteristic Information Having a Non-Planar Prism," Serial No. (to be assigned), Attorney Docket No. 1823.0820004, by McClurg *et al.*, filed concurrently herewith and incorporated in its entirety herein by reference.

[0032] FIG. 3 depicts a cross-sectional view of an exemplary non-planar prism 320 in accordance with an embodiment of the present invention. Non-planar prism 320 has an opening 322 running along an axis of symmetry 324. Opening 322 is defined within an area 326 of non-planar prism 320 that has a non-planar first section 328 and a substantially planar second section 332. A first surface 336 of first section 328 is shaped so as to provide the non-planar aspect to prism 320. The non-planar shape is preferably approximately conical, but can also be curved, spherical, or the like, so long as a second surface 334 provides total internal reflection of incident beam.

[0033] Exemplary live scanners having non-planar prisms are described in co-pending U.S. Patent Application entitled, "System for Obtaining Print and Other Hand Characteristics Using A Non-Planar Prism," Serial No. (to be assigned), Attorney Docket No. 1823.0820002, by McClurg *et al.*, filed concurrently herewith and incorporated herein by reference in its entirety, co-pending U.S. Patent Application entitled, "Non-planar Prism Used in a System for Obtaining Print and Other Hand Characteristic Information," Serial No. (to be assigned), Attorney Docket No. 1823.0820003, by McClurg *et al.*, filed concurrently herewith and incorporated herein by reference in its entirety, and co-pending U.S. Patent Application entitled, "System Having A Rotating Optical System And A Non-Planar Prism That Are Used To Obtain Print And Other Hand Characteristic Information," Serial No. (to be assigned), Attorney Docket No. 1823.0820004, by McClurg *et al.*, filed concurrently herewith and incorporated herein by reference in its entirety.

[0034] Display processing module 280 is configured to communicate information concerning the status of the image scanning and capturing process to one or more output devices. For example, display processing module 280 may generate a preview display of the captured image data at or near real-time as radial scan lines are being captured. Display processing module 280 may also activate LEDs or audio devices in an output device to indicate a scan is in process or other status information. An exemplary method of generating a preview display is described in co-pending U.S. Patent Application entitled, "Method of Generating a Preview Display in an Hand Print Capturing System Using a Non-Planar Prism," Serial No. (to be assigned), Attorney Docket No. 1823.082000A, by McClurg *et al.*, filed concurrently herewith and incorporated in its entirety herein by reference

[0035] FIG. 4 depicts a flowchart of a method 400 for converting image data captured in a first coordinate system format to a second coordinate system format in accordance with the present invention. The flowchart 400 will be described with continued reference to the example image conversion system 150 described in reference to FIGS. 1 and 2, above. However, the invention is

not limited to that embodiment.

[0036] Method 400 includes a calibration (or pre-processing) process 410 and a run-time process 420. Calibration process 410 can be carried out anytime prior to run-time. Calibration process 410 involves the calibration of arrays, tables, and parameters used by the image conversion system 150 for conversion processing (step 430). Step 430 is described in further detail below with respect to FIG. 5.

[0037] Run-time process 420 is initiated when the image conversion system 150 receives raw first coordinate system image data from a live scanner (step 440). In step 445, the raw first coordinate system image data are stored in memory 156.

[0038] Prior to the start of run-time process 420, a scan is initiated in a live scanner (step 425). The scan can begin automatically or manually (e.g., in response to a user selection at a user interface to initiate a scan). During the scan, the electro-optical system 225 captures image data from a platen surface scanning area. The captured image data can include raw image data representative of a print pattern from which biometric data (such as finger minutiae, ridge data, and/or other finger and hand characteristic information) can be extracted. This image data is communicated to the image conversion system internally or via a data network.

[0039] FIGs 4A-C illustrate the scanning and capturing process in a live scanner having an exemplary conical platen surface in accordance with an embodiment of the present invention. FIG. 4A illustrates the placement of a subject's hand on a conical platen surface during the scan. FIG. 4B shows a cross-sectional view of a portion of the live scanner performing the scan. In this embodiment, illumination source 215 is positioned in opening 322 of non-planar prism 320. Based on the reflection angle of a beam from illumination source 215 off the second surface 334, the electro-optical system 225 captures pixel images. Electro-optical system 225 can rotate about axis 324 (e.g., axis of rotation) to capture images from surface 336.

[0040] FIG. 4C illustrates a scan of a print pattern placed on the conical platen

surface depicted in FIGs. 4A and B. As shown in the example diagram in FIG. 4C, a linear camera 227 having a length between a radius $r_{initial}$ and $r_{final}$ moves from an initial angular position $\sigma_{initial}$ along an arcuate path y to a final angular position $\sigma_{final}$. In this way, the linear camera 227 sweeps out a path in polar space over an area between angular positions $\sigma_{initial}$ and $\sigma_{final}$ and radial positions $r_{initial}$ and $r_{final}$ .

[0041] As the linear camera scans, radial scan lines of image data (referred to herein as polar space raw image data) are successively captured and communicated to the receiving module 152 of the image conversion system 150. The received polar coordinate system raw image data are stored in memory 156 (step 445). The stored polar system raw image data are shown schematically as an array of radial scan line images 428 in FIG. 4C. In practice, because of the conical platen surface, image data is captured and stored at a higher resolution (e.g., a greater dpi) in the scanning area near the top of the conical platen surface that is, closer to radial position $r_{initial}$, compared to the scanning area near the base of the conical area, that is, closer to radial position $r_{final}$. The capture and storing of radial scan line image data proceeds until the linear camera has swept a desired scanning path.

[0042] The process of performing a scan in a live scanner having a non-planar prism is described in co-pending U.S. Patent Application entitled, "Methods For Obtaining Print And Other Hand Characteristic Information Using A Non-Planar Prism," Serial No. (to be assigned), Attorney Docket No. 1823.0820007, by McClurg *et al.*, filed concurrently herewith and incorporated in its entirety herein by reference.

[0043] Returning to FIG. 4, in step 450, the coordinate conversion module 154 converts the stored raw first coordinate image data to second coordinate image data using the conversion data generated in step 430. In an embodiment of the present invention, conversion step 450 is not initiated until the scan is completed and all the captured image data has been received by the image conversion system 150. In an alternate embodiment, conversion step 450 begins after sufficient captured image data to perform conversion has been

received. In this embodiment, the conversion step occurs in parallel with the scan. Step 450 is described in further detail below with respect to FIG. 6.

[0044] After the conversion process is completed, the conversion coordinate module 154 stores the converted second coordinate system image data in memory 156. Other optional image processing operations such as filtering can be performed on the converted second coordinate system image data prior to step 460 or after storage. Second coordinate system image data can then be output for display or further processing by downstream applications (step 470). Examples of further processing operations are extract and match, store and forward, or other print processing or image processing operations. Run-time process 420 is repeated for each scan performed in an associated biometric imaging system.

[0045] In an embodiment of the present invention, after step 470, the display processing module 280 generates a preview display of the converted image. In this embodiment, the display processing module 280 determines a representative pixel value for pixels in a group of (x,y) coordinates using a decimation technique. For example, the processing module may select every $n^{th}$ pixel as the representative pixel value for that group. Alternatively, the processing module may select a pixel at random. The representative pixel values are then plotted at a corresponding output device and displayed in a display window. In this way, a preview display can be provided quickly. In an alternate embodiment, the representative pixel values can be generated prior to step 470, during the conversion process.

[0046] FIG. 5 depicts a flowchart of calibration (or pre-processing) process 410. In step 512, the conversion coordinate module 154 generates the conversion data. In an embodiment, the coordinate conversion module 154 generates one or more conversion data arrays in step 512. Each conversion data array contains data necessary for converting captured first coordinate system image data to a second coordinate system format. Generation step 512 includes creating an array entry for each pixel in the defined output area of the second coordinate system. The conversion data array maps each pixel to a

position in the first coordinate system. Each conversion data array entry includes second coordinate system coordinates and second coordinate system offset values.

[0047] FIG. 5A and B illustrate the generation of a conversion data array in a system having a polar first coordinate system and a rectangular second coordinate system. FIG. 5A shows an illustrative graph 550 of a polar coordinate system. Graph 550 has multiple radii 552 and angles 554. Point $A_{RECT}$ 556 represents the mapping of a rectangular coordinate ($x_A$ , $y_A$) into the polar coordinate system.

[0048] FIG. 5B illustrates a conversion data array 570 associated with the graph of FIG. 5A. Conversion data array 570 includes a plurality of rectangular coordinate system (x,y) entries 572. Each respective (x,y) entry has an associated polar coordinate (r, $\sigma$) 574 and associated polar offsets ($r_{offset}$, $\sigma_{offset}$) 576 for example, point $A_{RECT}$ 556 having coordinates ($x_A$ , $y_A$) in (x,y) coordinate space has an entry 578 that contains polar coordinates ($r_i$, $\sigma_i$) and polar offsets ($r_{offsetA}$, $\sigma_{offsetA}$). As shown in graph 550, polar coordinates ($r_i$, $\sigma_i$) point to a point $A_{POLAR}$ in polar space, which is at or near point $A_{RECT.}$ The polar offsets ($r_{offsetA}$, $\sigma_{offsetA}$) identify displacements between point $A_{POLAR}$ in polar space and point $A_{RECT}$ in rectangular coordinate space as shown in graph 550. The present invention is not intended to be limited to conversion data array 570. Other types of data structures and/or coordinate space conversions can be used, as would be apparent to a person skilled in the art given this description.

[0049] FIG. 8 depicts a mapping 800 of a conical platen surface 890 onto a rectangular area 895. As can be seen in FIG. 8, portions of the rectangular area 895 do not overlap with he conical platen surface 890. For (x,y) coordinates located in these portions, no data exists for conversion. Therefore, coordinate conversion is not required for these (x,y) coordinates. To improve efficiency, during generation of a conversion data array, the coordinate conversion module 154 stores a flag or a data value in the entry for each non-overlapped (x,y) coordinate. During run-time process 420, the flag or value

indicates to the coordinate conversion module 154 that no computation is necessary for this (x,y) coordinate. The coordinate conversion module 154 then proceeds to the next (x,y) coordinate to be processed. In this embodiment, when the image is displayed, the display device will paint non-overlapped (x,y) coordinates with a default value such as white.

**[0050]** Returning to FIG. 5, after the conversion data array is generated, the conversion coordinate module 154 stores the conversion data array in memory 156 (step 516). In addition to generating and storing a conversion data array, other calibration (e.g., camera calibration) or pre-processing operations can be carried out as would be apparent to a person skilled in the art given this description. Also, generating and storing a conversion data array are described with respect to calibration and pre-processing. In alternate embodiments of the invention, the steps of generating and storing the conversion data array are carried out in real-time during run-time processing.

**[0051]** FIG. 6 depicts a process loop 450 for converting first coordinate space image data to second coordinate system image data based on the stored conversion data. Process loop 450 is described in reference to a first polar coordinate system and a second rectangular coordinate system such as depicted in FIG. 5A and 5B. Persons skilled in the relevant art(s) will recognize that other first and second coordinate systems can be used without departing from the spirit or scope of the present invention.

**[0052]** Process loop 450 is performed for each pixel (x,y) in an output rectangular area. An output rectangular area can correspond to an area obtained when a conical platen surface is flattened as shown in the mappings of FIG. 7-8. In step 652, the coordinate conversion module 154 retrieves conversion data associated with the second coordinate system pixel being processed from the conversion data array. In the example array 570, the retrieval for a given pixel at coordinates (x,y) would obtain values for corresponding polar coordinates ($r$, $\sigma$) and polar offsets ($r_{offset}$, $\sigma_{offset}$). This retrieved conversion data identifies a region in polar space that corresponds to the particular pixel. For example, as shown in graph 550, in the case of a look

up for a pixel at rectangular space coordinates ($x_A$, $y_A$), polar coordinate values ($r_i$, $\sigma_i$) are retrieved which correspond to a point in polar space near the pixel at point ($x_A$, $y_A$).

**[0053]** In step 654, one or more samples of the captured image data in first coordinate system format are retrieved from memory 156. The samples are selected based on the retrieved conversion data array entry. In particular, samples at or near polar coordinate values (r, $\sigma$) are selected. In step 656, the coordinate conversion module 154 interpolates the retrieved samples to obtain the pixel value for a respective pixel in rectangular image space. The coordinate conversion module 154 uses a weighting in the interpolation, which is based on the retrieved polar offsets ($r_{offset}$, $\sigma_{offset}$).

**[0054]** Any conventional sampling and interpolation techniques can be used in steps 654 and 656, including but not limited to, bi-linear interpolation, and cubic spline interpolation (e.g., a Catmull-Rom interpolation). In the example shown in graph 550, sixteen samples denoted by an "X" may be retrieved from the captured polar space image data at or near the looked up polar coordinate values ($r_i$, $\sigma_i$). Weighting coefficients for a Catmull-Rom interpolation are then determined based upon the looked up polar offsets ($r_{offset}$, $\sigma_{offset}$). In this way, a sampled and interpolated value is obtained from captured polar space image data that corresponds to a pixel value in rectangular image space. High resolution in the raw image data is maintained.

**[0055]** Method 600 describes the coordinate conversion module 154 calculating the weighting coefficients during run-time process step 450. In an alternate embodiment, a weighting coefficient table for each interpolation method supported could be generated and stored during or prior to calibration. In this embodiment, in step 656, the coordinate conversion module 154 accesses the appropriate weighting coefficient table to determine the weighting used during interpolation.

**[0056]** In an alternate embodiment of the present invention, method 600 also includes the ability for a user to configure various aspects related to the scan, conversion, and/or display. In this embodiment, a user may input criteria to be

used during conversion and/or display processing. For example, a user may input a desired output resolution (e.g., 600 dpi, 1200 dpi, etc.), a desired output size, and/or a desired output location. If the coordinate conversion module supports input criteria, the coordinate conversion module 154 may generate multiple data arrays. For example, the coordinate conversion module may generate one array for use if 600 dpi is selected, a second array for use if 800 dpi is selected, a third array if 1200 dpi is selected, and so on. These multiple data arrays may be generated dynamically upon input by the user or may be generated during or prior to calibration.

**[0057]** In this embodiment, a user may also input goal criteria such as reducing aliasing, improving focus, and/or improving contrast. Based on these criteria, the coordinate conversion module 154 selects the appropriate parameters for meeting these goals. For example, the coordinate conversion module 154 may select the best interpolation method to be used during conversion to meet the user input criteria. In an alternate embodiment of the invention, the live scanner may automatically generate the criteria to be used for the scan.

**[0058]** In an alternate embodiment, the orientation of a print being displayed can also be adjusted. During conversion processing, the image conversion system 150 determines the center of the scanned image (e.g., the center of the handprint or the center of the fingerprint). For example, the image center can be represented by a coordinate point or by horizontal and/or vertical lines. The system 150 then assigns the image center as the root for display and conversion processing. By identifying the center, the coordinate conversion module 154 can rotate the orientation of the print image during conversion processing. In this way, the print image can be displayed in the correct orientation without requiring additional processing to correct the orientation. In an alternate embodiment, the orientation can be adjusted after conversion by the coordinate conversion module 154 or by the display processing module 280.

[0059] FIGS. 7 and 8 illustrate point-by-point how mapping between a polar coordinate system and a rectangular coordinate system can be performed for a conical prism using the above described methods and systems. FIG. 7 illustrates where polar coordinates and rectangular coordinates approximately overlap before conversion. FIG. 8 illustrates how a few polar coordinate system points on the conical platen surface correlate to rectangular coordinate system points.

[0060] FIGs. 9-10 depict alternative embodiments of the image conversion system described above. FIG. 9 depicts a system 900 having a live scanner 910 coupled to an external image conversion system 950 via a data network 960. In an alternate embodiment, two or more live scanners are coupled to the external image conversion system 950 via data network 960. Live scanner 910 and image conversion system 950 may also be coupled to a display processing module 980. Electro-optical system 225 captures raw image data and communicates the raw data to external image conversion system 950 via data network 960. Network 960 can be any type of network or combination of networks known in the art, such as a local area network (LAN), a wide area network (WAN), an intranet, or an Internet. In an embodiment of the present invention, network 960 is a data link between the live scanner 910 and the external image conversion system 950.

[0061] FIG. 10 depicts a system 1000 incorporating a distributed architecture in accordance with an alternate embodiment of the present invention. System 1000 includes a live scanner 1010 having an internal image conversion system 1050A coupled to an external image conversion system 1050B via a data network 1060. Image conversion processing is distributed between image conversion systems 1050A and 1050B. For example, internal image conversion system 1050A may include the calibration logic and external image conversion system 1050B may include the conversion logic. As will be appreciated by persons skilled in the relevant art(s), other architectures for distributing image conversion processing among multiple image conversion systems can be used without departing from the spirit or scope of the

invention.

[0062] The terms "biometric imaging system," "scanner," "live scanner," "live print scanner," "fingerprint scanner," and "print scanner" are used interchangeably, and refer to any type of system which can obtain an image of all or part of one or more fingers, palms, toes, foot, hand, etc. in a live scan.

Conclusion

[0063] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the invention. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.